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Title: Opportunities and Advancement in LANL NCS

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Opportunities and Advancement in LANL NCS

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October 2019

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LA-UR-19-TBD

Outline

October 2019

University of Tenness, Knoxville

- Example NCS Evaluation
- Example NCS Support
- Example NCS R&D
- LANL NCS Pipeline

NCS Evaluation of a Fissionable Material Operation

Team Based Approach

Criticality Safety Evaluation Process

Process Description

- Requirement document assists the CSED

Normal and Credible Abnormal Conditions

- Hazard analysis meeting assists in developing the process conditions

Technical Analysis

- Use of existing technical work (cf. pertinent CSEDs, TECHs, etc.)
- Develop new technical bases

Evaluation Process

NCS Requirements/Controls

- Limits on controlled parameters are derived from analysis
- Additional restrictions typically used to make the analysis tractable or in double-contingency arguments

Summary, Conclusion, Appendices

Independent Review for Adaquacy

- Intermediate Review of a new, or some/most major revisions
- Independent Review of a DRAFT document that is anticipated to be issued, not required for minor revisions
- Quality Review of a document that is anticipated to be issued
- DC/RO review of the master document

Signatures

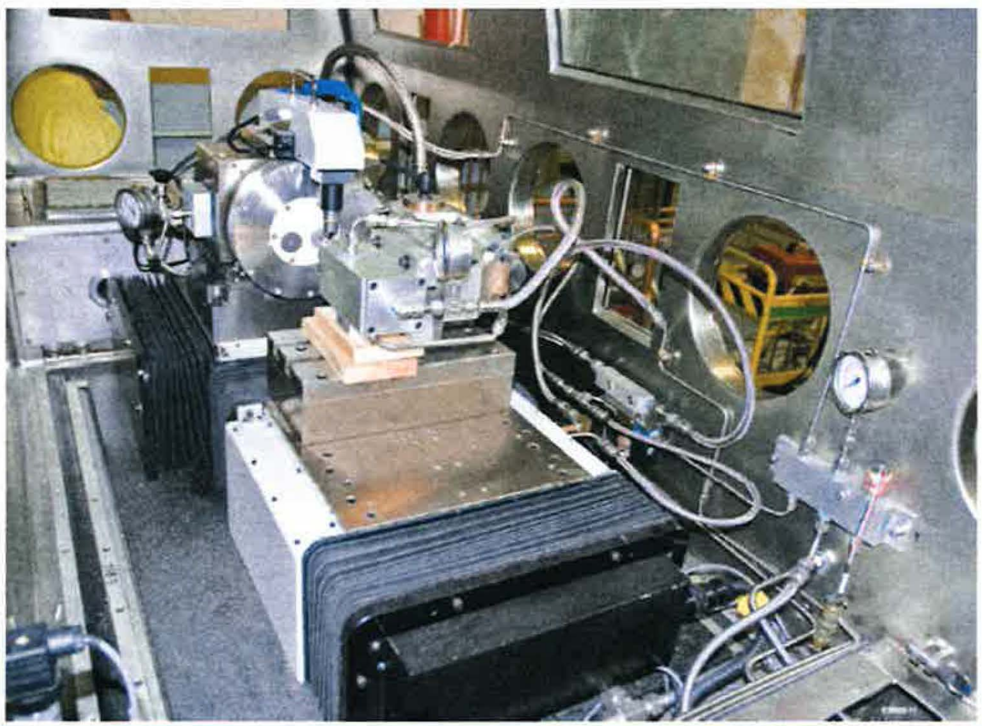
Slide 9

General Location Description

- Boundary of the location up to the spool face
- Separation to adjacent location(s)
- Fire suppression system present in the room

Specific Location Description

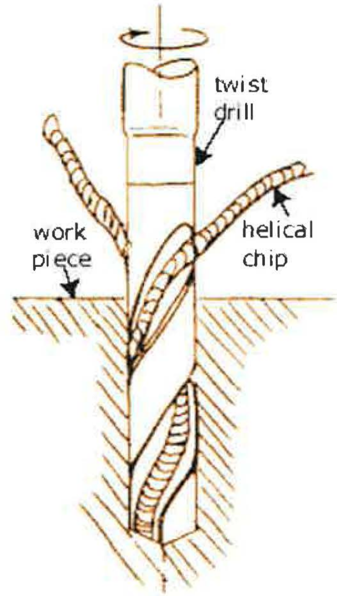
- Atmosphere
- Machine base (e.g., granite, steel, etc.)
- Local structures (e.g., Subfloors, shelves, etc.)
- Machine (e.g., drill, mill, lathe)
- Support systems (zone 1, compressed gas, dry vacuum, etc.)

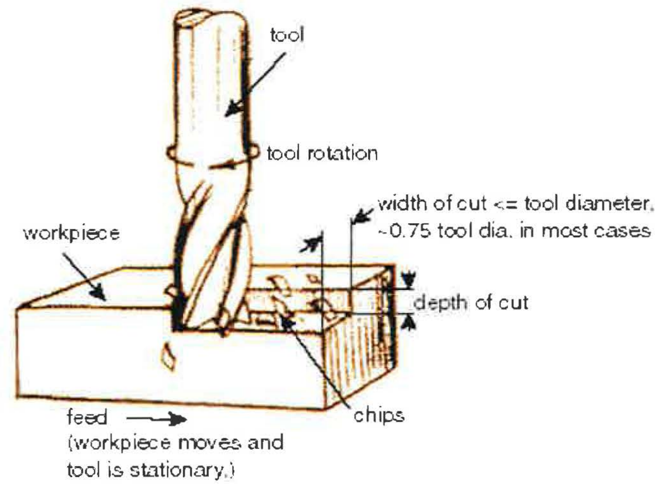


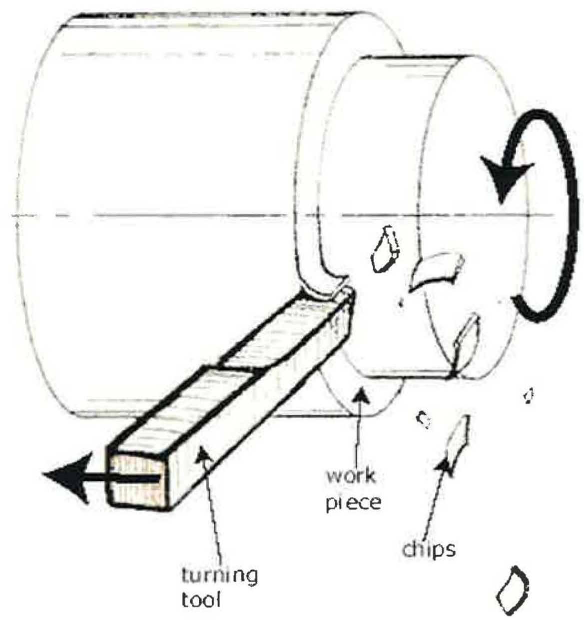
Slide 11

Glovebox Operations

- Material Handling
  - Containers, shielding, special concerns, etc.
- Machining (e.g., drill, turn, mill)
  - Main products
    - Metal samples
    - Small shapes
    - Large shapes
  - By-products
    - metal turnings
    - waste







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Misc. Activities

- Staging
  - Use of supplies, tools, tooling
- Maintenance, Housekeeping, Hold-up
  - Limited quantities of fluid
  - Additional tools, tooling, equipment my be used

Proposed NCS Requirements

CRITICALITY SAFETY REQUIREMENTS	
Administrative Controls	
Pu in Metal	≤ 6000 g

Additional Restrictions

- Plutonium in Hemishells shall have an inside diameter ≥ 2.0 in.
- Uncontainerized Pu in turnings shall be ≤ 520 g.

Normal Conditions

- Allowed limit of material
  - Essentially un-moderated
  - Isolated from nearby operations
- Interaction
  - 6 inches provides sufficient isolation
- Incidental neutron reflection
  - 1 inch water reflection on external surfaces bounds reflection considerations
- Nuisance spills
  - Nature of activity precludes > 2-L
  - 2-L of fluid is demonstrated subcritical

Misc. Process Conditions

- Maintenance, Housekeeping, Hold-up
  - Gram-level quantities
- Routine housekeeping
  - Considerations of lubrication system
    - QC requirements
    - Nature of activity
    - Location of lubrication system
    - Usage of lubrication system

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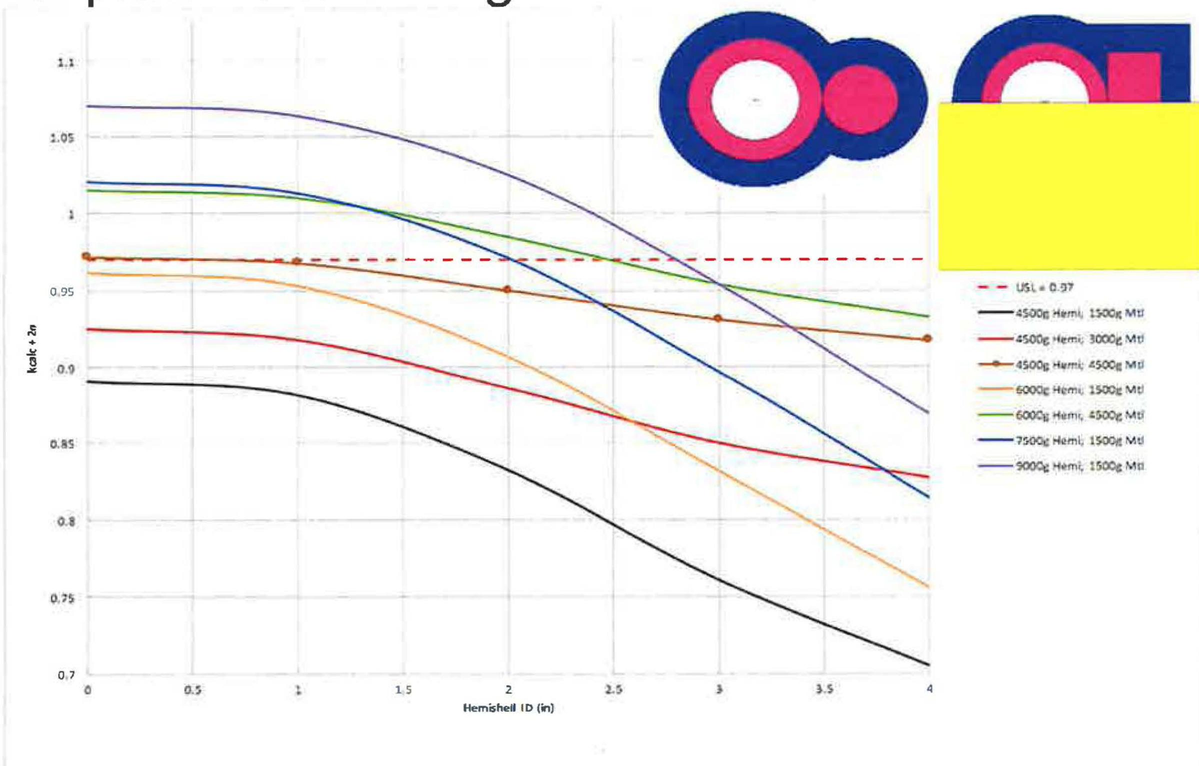
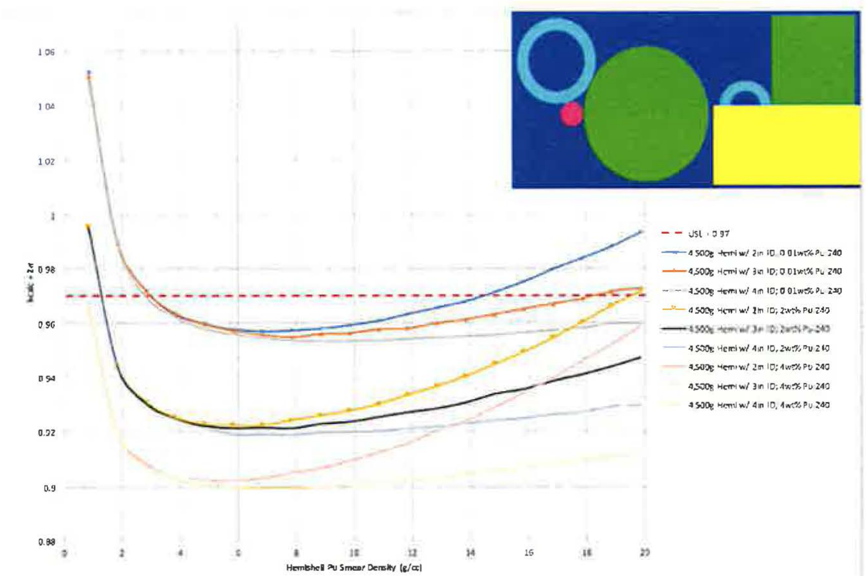
Loss of Mass Control

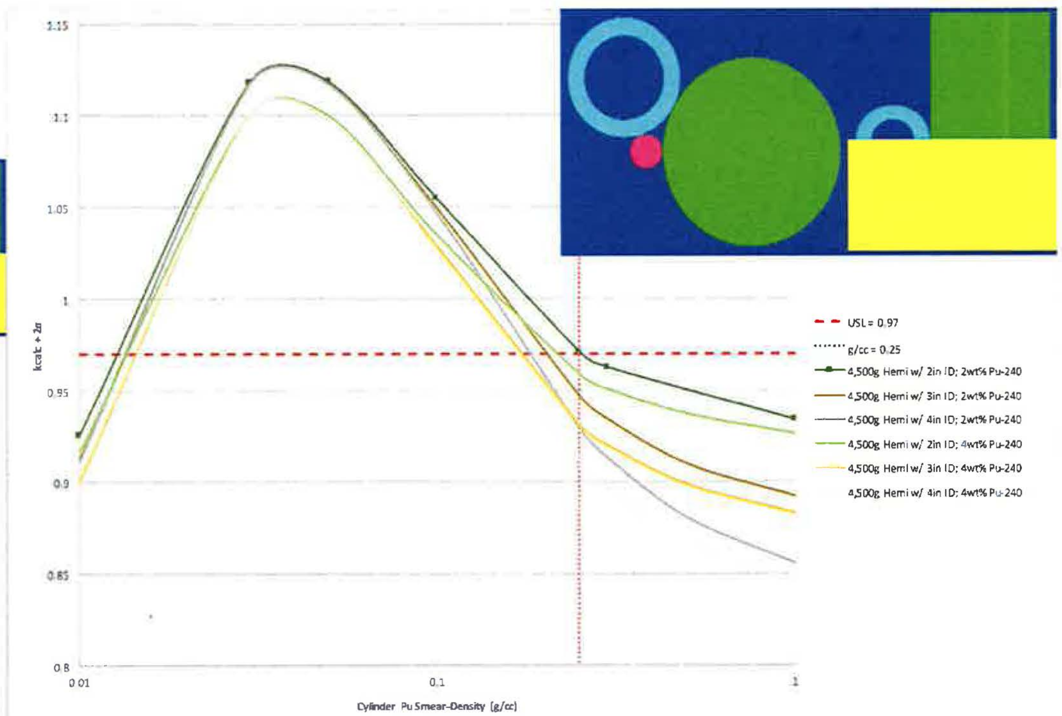
- Over massed container
- Additional (permitted) item
- Inaccurately identified material
- Plutonium turnings not in water-resistant container
- Overmass of plutonium turnings



Abnormal Conditions with Water

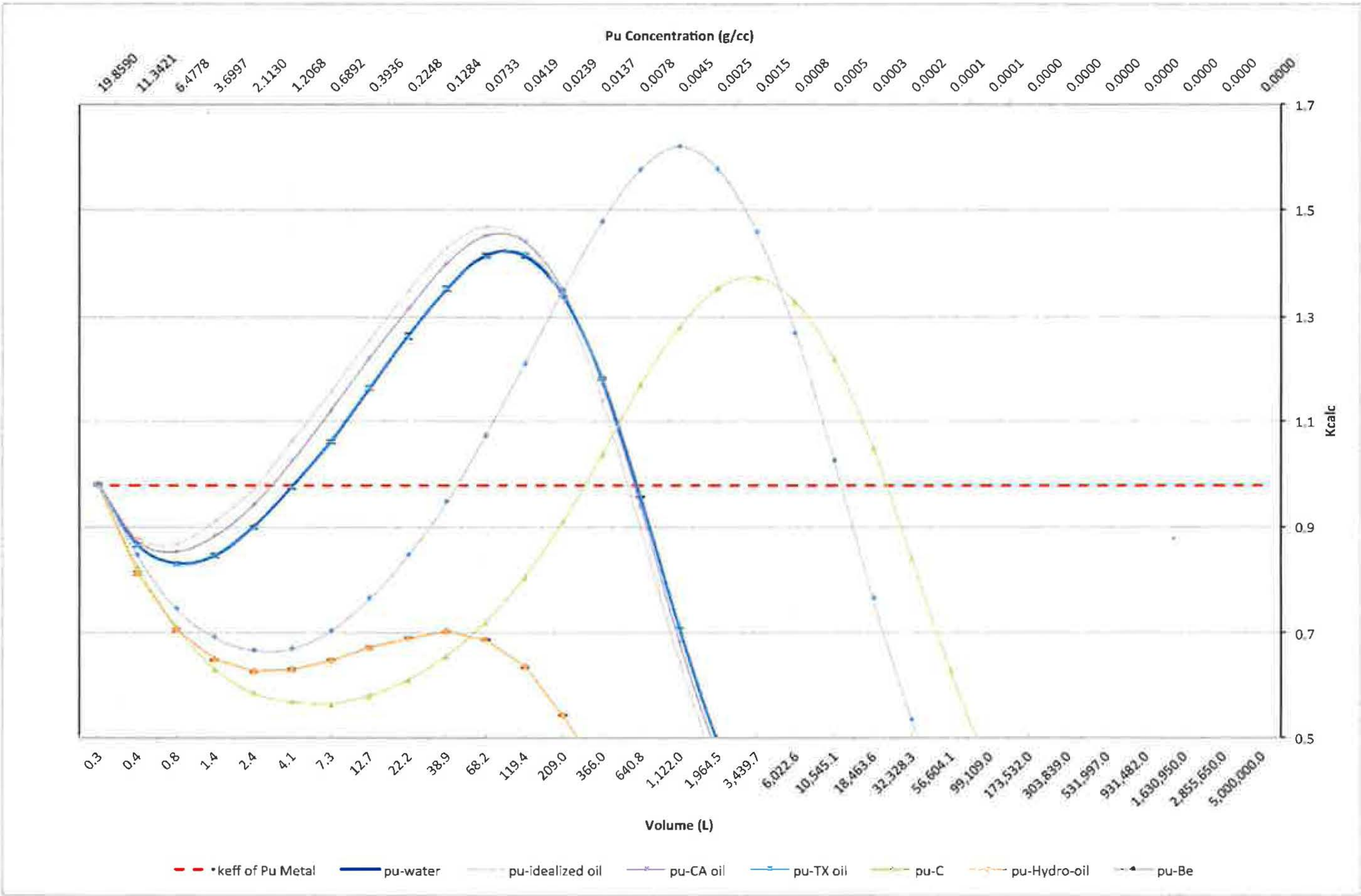
- Loss of Moderation Control
  - Water ingress
- Loss of Reflection Control
  - Bounded by full flooding
  - Full reflection from oil not credible





Abnormal Conditions with Oils

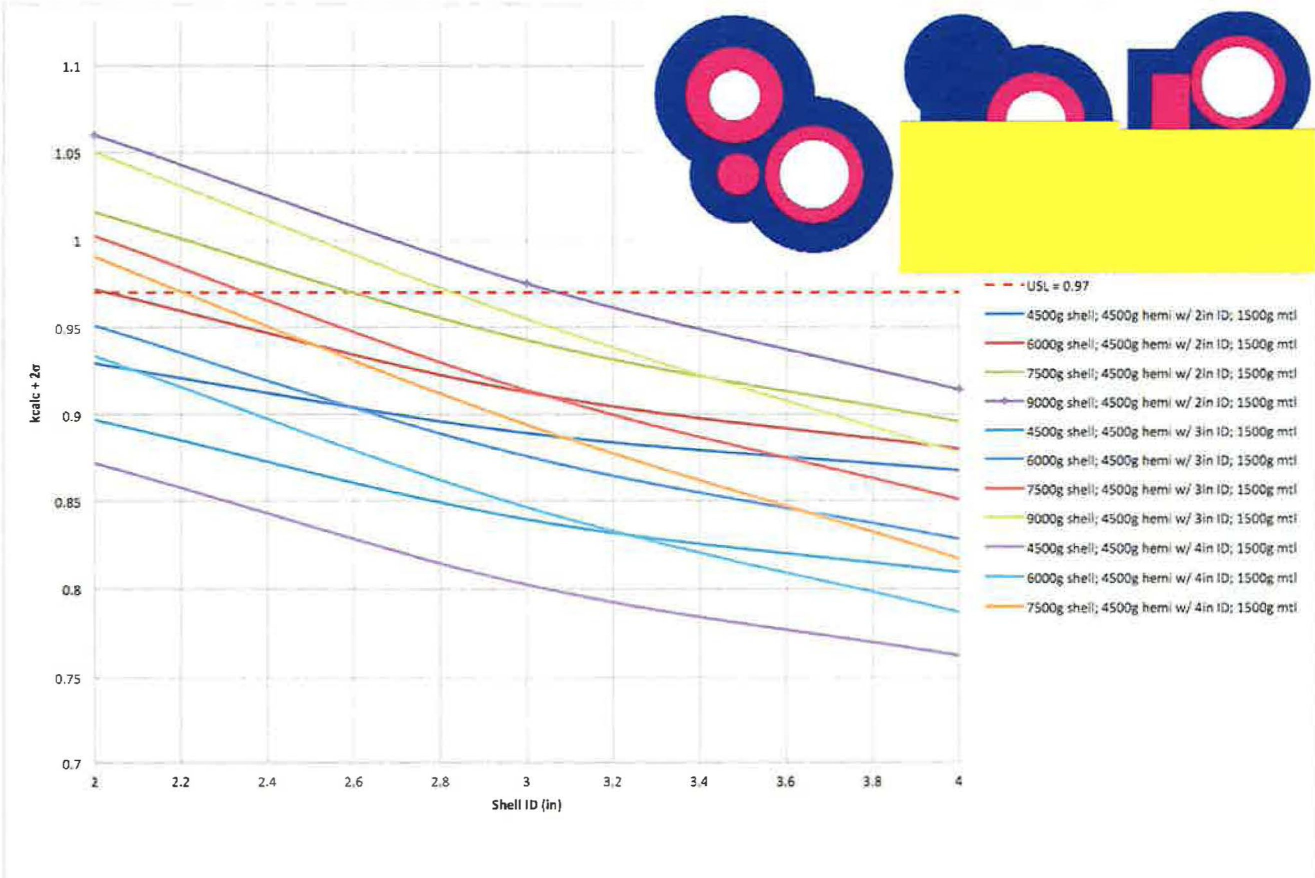
- Loss of Moderation Control
  - Oil from lubrication system
  - Fluid from the bubbler



Loss of Geometry and Spacing Controls

- Hemishell(s) not satisfying geometry requirement
- Operational mishap deforms a hemishell (e.g., drop)
- Machining mishap deforms a hemishell (e.g., bad cut)
- External event (e.g., seismic)
- Loss of Interaction
  - Staging of metal within a hemishell
  - Movement of fissionable material within 6-in
  - Introduction of container of Pu in Oxide
  - Introduction of Shell

Loss of Geometry and Spacing Controls



Design Basis Events

- Seismic event with subsequent intro of water
- Fire event with subsequent intro of water
  - Room fire
  - Glovebox fire
  - Use of fire fighting agents

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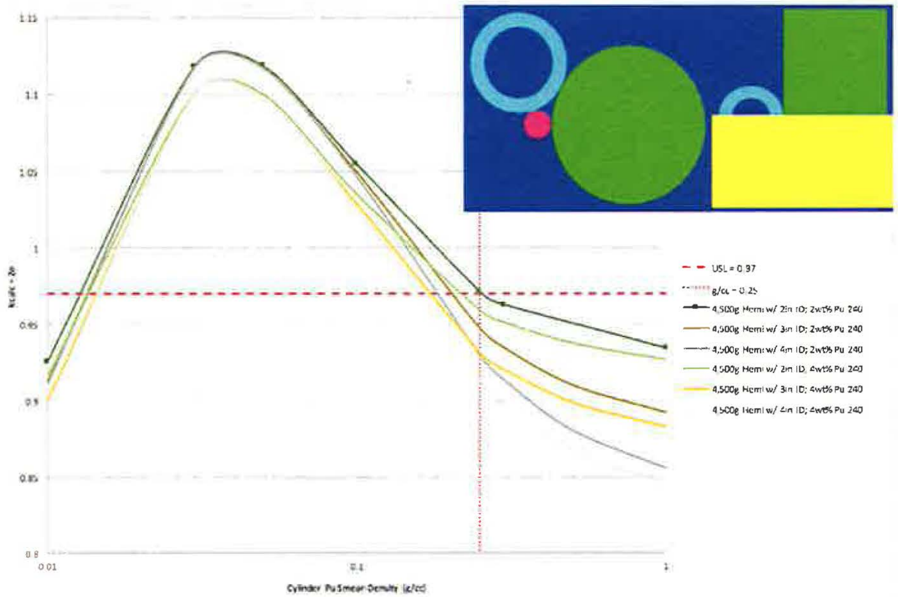
Proposed NCS Requirements

CRITICALITY SAFETY REQUIREMENTS	
Administrative Controls	
Pu in Hemishells	≤ 4500 g
AND	
Pu in Metal	≤ 1500 g

<u>Additional Restrictions</u>

- Plutonium isotopic content shall be ≥ 2 weight % Pu-240.
- Plutonium in Hemishells shall have an inside diameter ≥ 3.0 in.
- Plutonium in Metal shall not be staged within a hemishell.
- Fluids not included in the oil lubrication system shall be limited to ≤2 L.
- Uncontainerized Pu in turnings shall be ≤ 1000 g.
- Containerized Pu in turnings shall be in a Water-Resistant container.

Safety Controls are Derived from Basic Physics and Engineering Principles



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NCS Support to the Accident Response Group

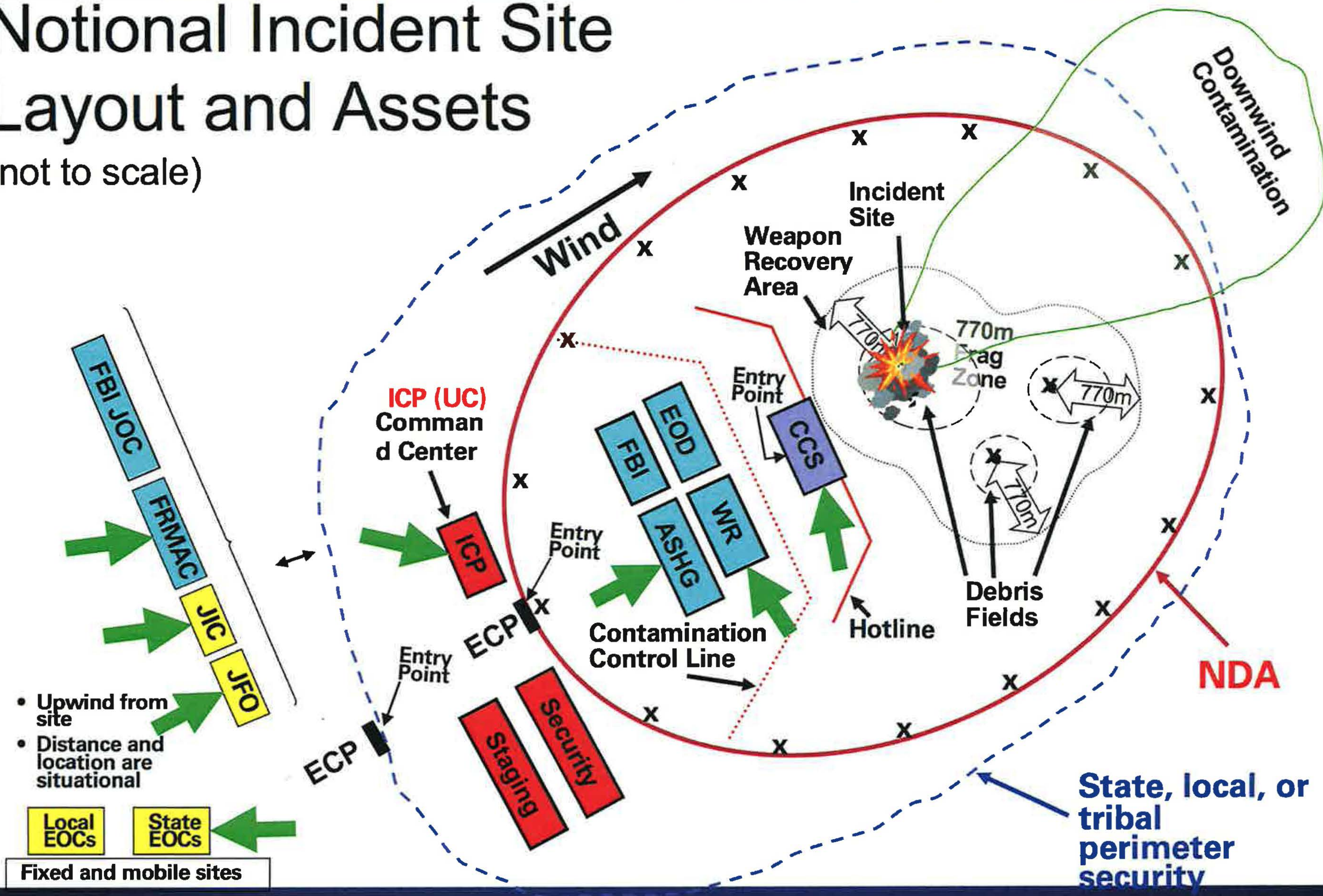
Accident Response Group (ARG) Mission

- Provide world-wide **support** to the Department of Defense (DoD) in resolving incidents and accidents involving nuclear weapons or components in DoD custody at the time of the event.
- **Technical management** of the resolution of incidents / accidents involving nuclear weapons / components in Department of Energy custody (when NNSA is the Primary Authority) at the time of the event.

Scale of Effort during an ARG Response

Notional Incident Site Layout and Assets

(not to scale)

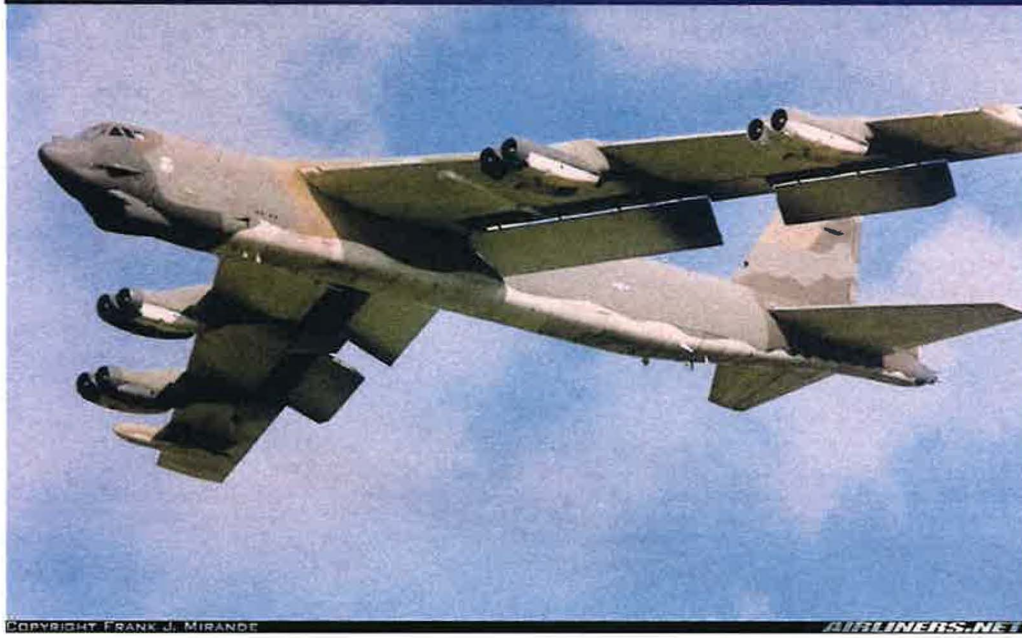


January 1968

- Looked like Lyndon Johnson was ahead in the polls
- Israel expropriated former Jordanian land in East Jerusalem
- England in a serious recession
- AT&T announced the creation of the 9-1-1 system
- Johnny Cash performed in Folsom State Prison
- Green Bay beats Oakland in Superbowl II
- Finale of *The Man from U.N.C.L.E*
- Red Lobster opens
- Battle of Khe Sanh in Vietnam
- Tet Offensive in Vietnam
- Operation Crosstie (experiment to see if an earthquake can be caused by a nuclear detonation
- Apollo 5 launched for mission to the Moon

- *THEN A PHONE CALL*

B-52 carrying 4 nuclear weapons has crashed....



Thule Accident – Crested Ice Recovery Project

- January 21, 1968 – B-52 bomber experienced a cabin fire forcing an abandonment of the craft prior to landing
  - Six survivors, one fatality
  - Carrying four B28FI nuclear weapons
  - Conventional explosives detonated and dispersed the nuclear material
- January 29 – Public announcement regarding the nuclear components from all 4 weapons being found
  - NOTE: No immediate actions were taken
  - Time was indeterminate, but it must be done before the ice shelf melted
  - Weapon and plane parts put into barrels, cans, drums, and containment vessels
- February 20 – Clean up complete
- March 30 – Termination of Crested Ice
- September 13 – Removal of last of vessels from Thule

Removal Techniques

- Weapons and Plane Debris
  - Put into ~217 drums and vessel
  - Each drum and vessel was assayed to obtain an estimated mass value
- Contaminated Snow
  - 7-ft x 10-ft x 4-ft plywood boxes used to move ~237,000 cubic foot of snow/ice
    - Estimated 3150 +/- 630 gram of plutonium contaminated in the blackened snow
    - An additional 350 g trapped in the ice
  - 67 25,000 gallon tanks at the Thule Base to melt the snow/ice
  - Final disposition in R-4360 containers back in the U.S.

Criticality Safety Guidance with Current Stockpile

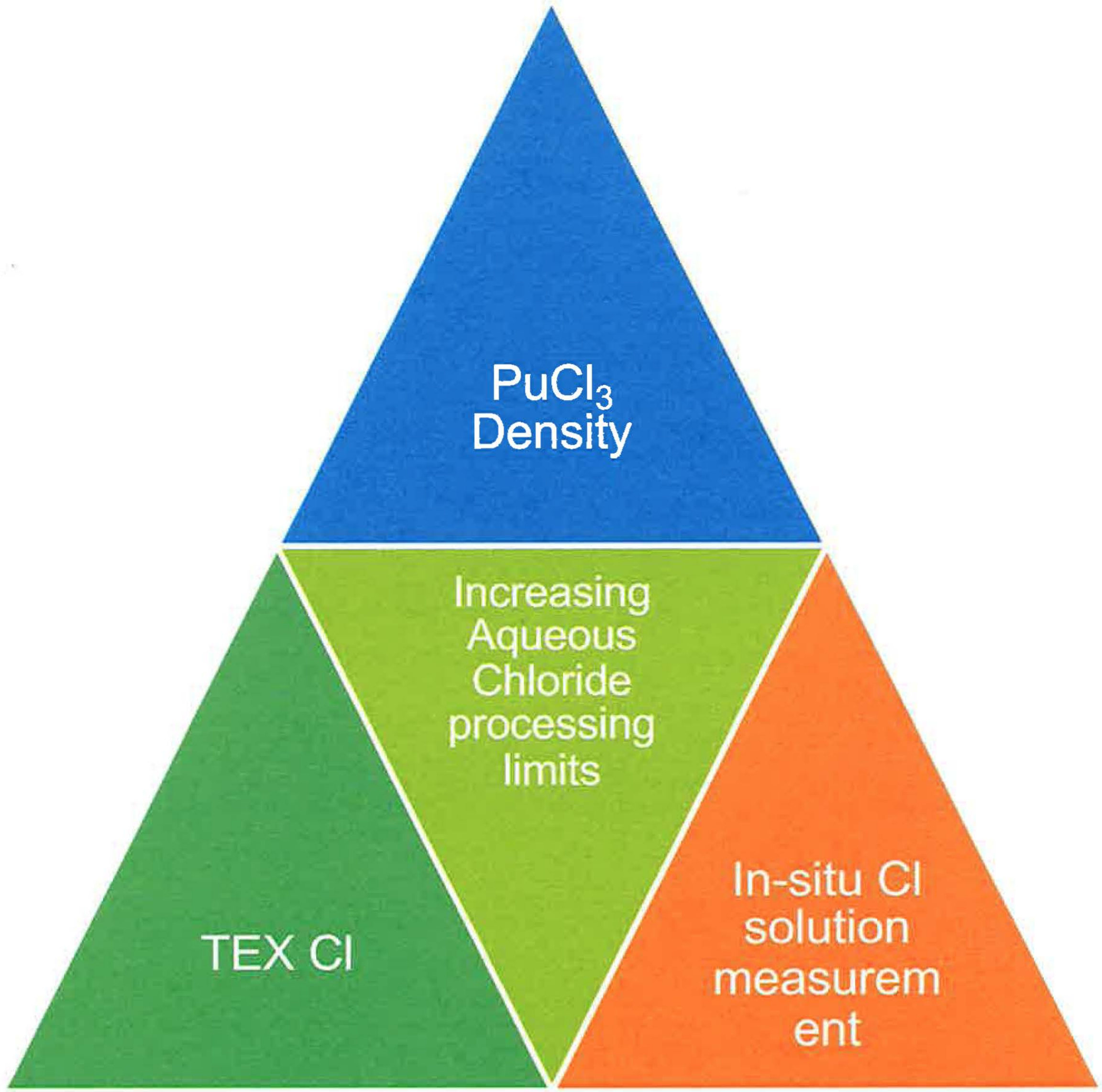
- Molten Slag or Pieces of fissile material
  - Limit each bag to ~1 kg of small pieces
  - Package larger pieces separately
  - Do not stack/collocate packaged pieces
    - Space each container > 6 inches apart from all other fissile material
- Contamination on Debris

Potential Future Efforts

- Technical report for fluids
  - Transportation of fissile solutions
- Technical report for solid pieces
- Technical report for contamination
- Criticality safety evaluation for potential abnormal weapon conditions
  - Forms: slag, pieces, solution, slurry
  - Conditions: Fire, Lightning induced, Flooding (submersed), Flooding (in a ditch), Internal corrosion, etc.
- Training module of criticality hazards
- Training module for initial response

LANL NCS R&D

The Idea – Increase processing limits



TEX Chlorine Critical Experiment(s)

Figure 1: Planet Machine in 1998 Loaded with Polyethylene Reflected and Moderated Highly Enriched Uranium Experiment with Silicon (HEU-MET-THERM-001)

TEX CI

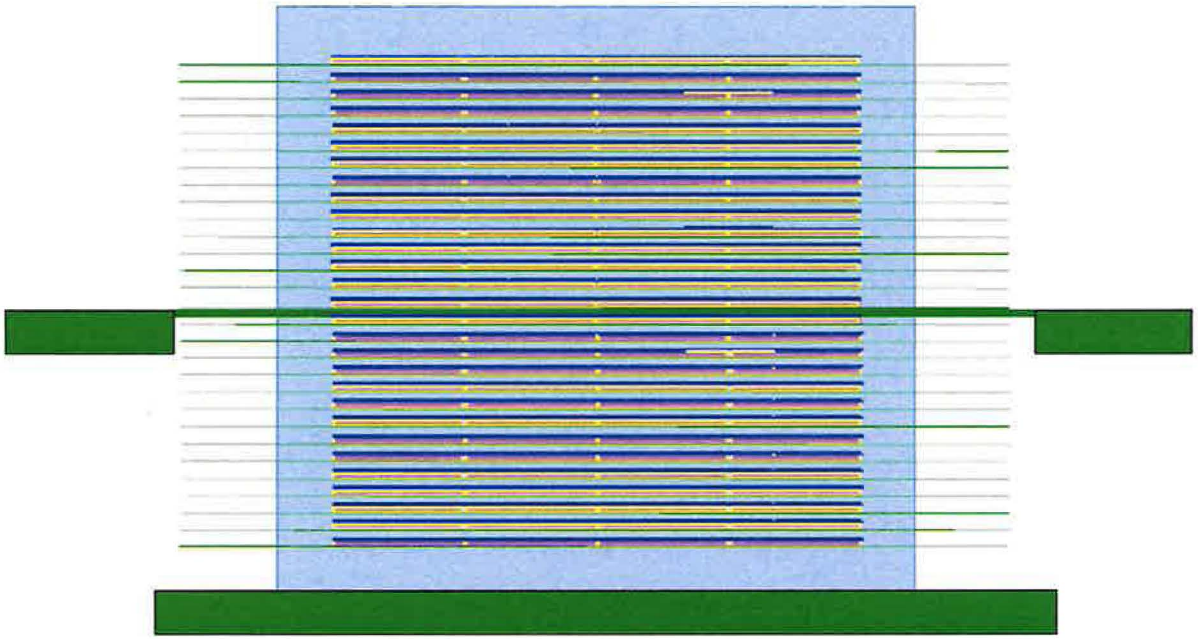


Figure 4. Experimental Configuration for Experiment 8: ZPPR Plate Layers with Tantalum and 0.1875 inches Interspersed Polyethylene. This experiment consists of 29 layers of Pu, an increase of 17 layers over the baseline case.

Reference: C. M. Percher, S. S. Kim, D. P. Heinrichs, *Final Design for the Thermal Epithermal eXperiments (TEX) with ZPPR Plutonium/Aluminum Plates with Polyethylene and Tantalum,* International Conference on Nuclear Criticality, Charlotte, NC, United States. 14 May 2015

TEX Cl

- Goal: Measure chlorine nuclear data for use in criticality safety analyses
- Lead: Catherine Percher, LLNL
- Team: Kristy Spencer (NCS); NEN-2 folks performing experiment at the Nuclear Criticality Experiment Research Center (NCERC), Device Assembly Facility (DAF), Nevada Nuclear Security Site (NNSS)
- Theory: TEX critical experiment apparatus allows critical data to be taken at thermal and epithermal energy ranges, simulating solution energy ranges

TEX CI

- Challenges:
  - Identifying pure/stable CI source
  - Optimize TEX design for anticipated energy spectra (use sensitivity data derived from model of in situ measurement)
- References:
  - C. M. Percher, S. S. Kim, D. P. Heinrichs, *Final Design for the Thermal Epithermal eXperiments (TEX) with ZPPR Plutonium/Aluminum Plates with Polyethylene and Tantalum,* International Conference on Nuclear Criticality, Charlotte, NC, United States. 14 May 2015

In-situ Measurement

- Goal: Use ANS-8.6 to take an in-situ measurement of aqueous chloride processing
  - $PuCl_3$ density law required to accurately model measurement conditions
- Lead: Nadia Chisler (NCS)
- Team: Bill Meyers, Teresa Cutler, Jesson Hutchinson (NEN-2)
- Theory: Use neutron multiplication measurements to estimate the amount of 'unit' required before the system is critical (subcritical multiplication measurement technique based on ANSI/ANS-8.6

In-situ Measurement

- Challenges: Facility support (potential challenge); NA-LA expressed support of the project
- References:
  - W. L. Myers, J. L. Alwin, N. D. Chisler, T. E. Cutler, J. D. Hutchinson, A. Sood, *Use of ANSI/ANS 8.6 Standard for Criticality Safety Applications in the Modern World of Advanced Simulation Capabilities,* ICNC 2019, Paris, France, 26 August 2019. (LA-UR-19-25398)

Plutonium Chloride ($PuCl_3$) Density

- Goal: Determine density law for $PuCl_3$ solution
  - –Required to use new chlorine nuclear data from TEX Cl experiment
  - –Required to model data taken from in-situ measurement
- Lead: Jen Alwin, XCP-3, LANL
- Team: Steve Willson, Dung Vu, Justin Cross (C-AAC); Alicia, Nadia (NCS)
- Theory: Isopiestic, Pitzer method for determining density

Plutonium Chloride ($PuCl_3$) Density

- Challenges:
  - Validate nitrate data
  - Emulating French measurement technique
- References:
  - Criticality Calculations Using the Isopiestic Density Law of Actinide Nitrates
  - Determination of fictive binary data for plutonium(IV) nitrate

The Players

- LANL – NCS Division
  - Alicia
  - Nadia – POC for In-Situ Measurement
  - Kristy – POC for TEX CI
- LANL – XCP-3
  - Jen Alwin – $PuCl_3$ Density work POC + MCNP integration of Cl nuclear data
- LANL – NEN-2
  - Dave Hayes, Bill Myers, Jesson Hutchinson, Theresa Cutler
- LANL – NCS Program
  - Brian Bluhm, NEN-DO
- LLNL
  - Catherine Percher – Cl nuclear data, thermal, epithermal

LANL NCS Pipeline

LANL NCS Pipeline Elements

Student: Upper Level BS or MS

Complete University Course

Summer Intership @ LANL

Internship Continues During Senior Semester(s) (assigments with LANL staff and univ. faculty)

LANL CSA Position

Universities Involved with the Pipeline

- Idaho State University (ISU)
- New Mexico State University (NMSU)
- Texas A & M University (TAMU)
- University of California Berkeley (UCB)
- Univ. of New Mexico (UNM)
- Note who's missing!

NM STATE

ISU BENGALS

Cal Berkeley UNIVERSITY OF CALIFORNIA

NUCLEAR ENGINEERING

Collaboration with Other National Laboratories

Los Alamos
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Y12
National Security Complex

Lawrence
Livermore
National
Laboratory

University Coursework Content

- First semester pipeline class
  - General NCS principles encompassing:
    - Fundamentals of rules, standards, and guides
    - Performing a hazard analysis
    - Elements of writing a CSE
    - Site specific applications
    - Other NCS principles
  - Guest lectures from LANL, Y12, and LLNL NCS personnel
    - in-person
    - video conference
  - LLNL offers hands-on experience to UCB students at their sub-critical reactor Inherently Safe Subcritical assembly (ISSA)

University Coursework Content (Cont'd)

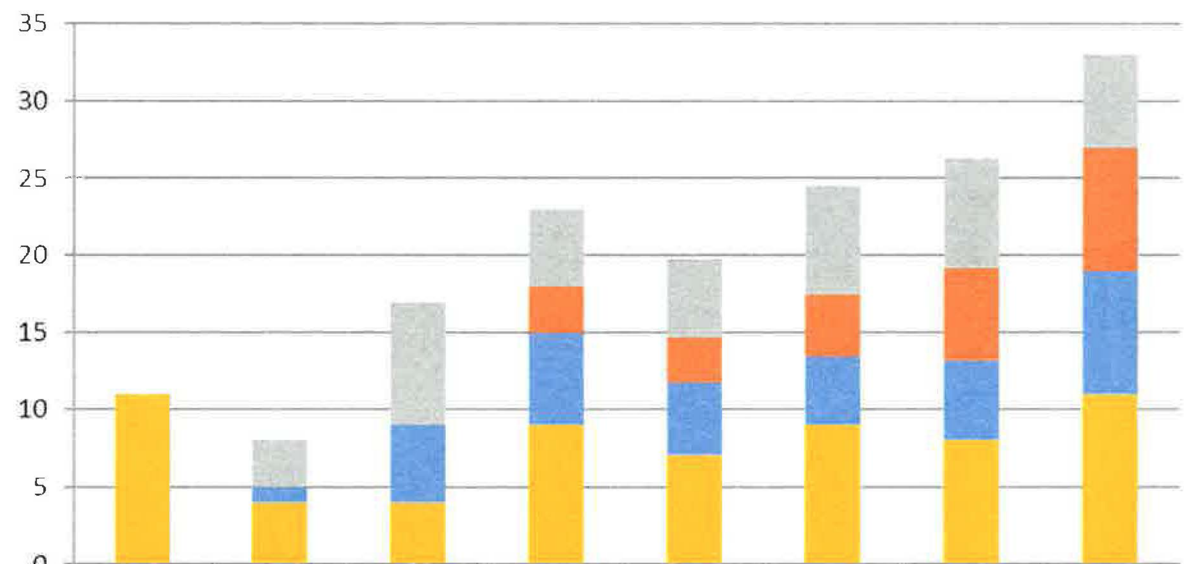
- Second semester pipeline classes currently only at TAMU
  - In-depth look at the elements of writing a formal evaluation
  - Students receive simulated plant processes in order to formulate a deliverable evaluation
    - Split into 2 LANL evaluation projects and 2 Y-12 evaluation projects
  - In-person and video conference lectures and meetings with corresponding groups
- Fall 2017 - NMSU offered single semester online course consisting of similar topics with in-person and recorded lectures by LANL NCS staff.
- (See next page for success stories….)

Pipeline Success

- 12 out of 19
  - Summer 2018 interns completed the fall 2017 pipeline class
- Four interns hired onto staff positions
  - Alex Brown from (TAMU)
  - Norann Calhoun (NMSU)
  - Kaelin Glover from (UNM)
  - Bradley Madahar (UC Berkeley)
- Three interns continuing from summer 2019
  - Miguel Avalos from (TAMU)
  - Rachael Bulso from (RPI)
  - Andrew Smiley (TAMU)

Students Hired on as Staff

NCS Staffing



	2011	2012	2013	FY14	FY15	FY16	FY17	FY18
LANL CSA-IT	0	3	8	5	5	7	7	6
LANL CSA-TQ	0	0	0	3	3	4	6	8
Contractor CSAs	0	1	5	6	4.75	4.5	5.25	8
LANL CSA-Q	11	4	4	9	7	9	8	11

Note: CSA = Criticality Safety Analyst, Q = Qualified, TQ = Task Qualified, IT = In-training.

Future Plans

- Continued support of pipeline classes and collaborations
- Continued support of internships
- Create degree/certificate university program
  - Degree/certificate in Nuclear Criticality Safety
  - Completion of many of the generic NCS qualification requirements

Conclusion

- LANL NCS has an future for you
  - Operational safety
  - Emergency safety
  - R&D
  - Training
- Work with world renowned scientists and engineers
  - In the building down the street, or
  - In an office just down the hall
- Life and play in Northern New Mexico
  - Personal life
  - Community life
  - Outdoor life